

New records of Procellariiformes in the Fernando de Noronha archipelago: who is looking out for them?

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Abstract. Little is known on seabirds of the order Procellariiformes which visit the Brazilian oceanic islands. Herein, we present new records of five birds found stranded in the Fernando de Noronha archipelago: *Fregetta tropica melanoleuca* Salvadori, 1908, *Ardeanna grisea* (Gmelin, 1789), *Puffinus lherminieri* Lesson, 1839, and *Hydrobates leucorhous* (Vieillot, 1818). Citizen-science platforms include only one documentation for each of these species, but there is potential for greater detection. Pelagic birds have rarely been reported in recent decades, and continued monitoring is needed for better understanding of their distribution patterns.

Key words. At-sea distribution, migratory birds, petrels, seabirds, South Atlantic Ocean, tropical region

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INTRODUCTION

Seabirds of the order Procellariiformes are mostly pelagic, and several species disperse widely (Warham 1990, 1996; Nevitt 2008). In general, these birds spend long periods at sea, only returning to land to breed or as visitors to stopover (Warham 1990; Weimerskirch and Robertson 1994; Guilford et al. 2009). The distributions of albatross and petrel species are related to the distance from their colonies and foraging areas (Warwick-Evans et al. 2021). Low-latitude regions harbour fewer species than subtropical, temperate, and polar regions, a global pattern that is true for all ocean basins (Chown et al. 1998; Davies et al. 2010). Brazilian region, which includes a large portion of the South Atlantic Ocean, has few breeding species of Procellariiformes, sheltering resident populations of *Pterodroma arminjoniana* (Giglioli & Salvadori, 1869) (Trindade Petrel) and *Puffinus lherminieri* Lesson, 1839 (Audubon's Shearwater) (Mancini et al. 2016). Although virtually all procellariiform species are regular non-breeding visitors or vagrants (Pacheco et al. 2021), Brazilian waters comprises an important feeding ground (Neves et al. 2006; Carlos 2009; Guilford et al. 2009; Daudt 2019).

Species-richness and abundance of Procellariiformes increases with latitude toward the south in Brazil (Carlos 2006; Daudt 2019). However, the distribution patterns of many of these species is inaccurate, possibly due to the paucity of surveys, and little or no effort to standardize surveys of pelagic species in this region (e.g. Neves et al. 2006; Barbosa Filho and Vooren 2007; Lees et al. 2015; Alvarenga 2018; Daudt 2019). In contrast to areas closer to the mainland, at-sea surveys have not been widely undertaken by ornithologists and citizen contributors (e.g. Franz et al. 2018; Valls et al. 2023), as these surveys require days on-board a ship and are costly. Climatic and marine conditions differ between the continental margin and oceanic islands (Longhurst and Pauly 1987; de Souza et al. 2013), and how these differences affect species' distribution still requires better understanding. Some previous authors have published on sporadic records of procellariiform species from both coastal and oceanic regions (Carlos 2006, 2009; Valls et al. 2023), and citizen-science initiatives have been widely used as an alternative source of occurrence and data on



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ecological processes of birds (Veit et al. 1996; Lagoze 2014; Sullivan et al. 2014). Much information has been added by birders, tourists, and volunteers, including geographic range extensions, effects of environment changes on bird communities, and results of monitoring programs over large geographic regions, including in areas of limited access (Dickinson et al. 2010).

One of the four oceanic island groups in Brazil is the Fernando de Noronha archipelago (hereafter FNA; ca. 03°52'S; 32°25'W at centre), situated 345 km off the northeastern mainland and within the Intertropical Convergence Zone (Rocha 1995; Teixeira et al. 2003). These volcanic islands are 323 m above sea level with a total land area of 26 km² and present different conditions from continental Brazil (Longhurst and Pauly 1987; Feitosa and Bastos 2007; de Souza et al. 2013; Santana 2015). The archipelago has two categories of protected areas, the Environmental Protection Area (which allows sustainable use; MMA 2017) and the National Marine Park (which is under strict protection; IBAMA 1990). The main island is the only exception, where a permanent human population of slightly over 3100 lives (IBGE 2022).

The FNA has the greatest diversity of bird species among Brazil's oceanic islands, which include 17 residents, 11 of them seabirds and six landbirds. Two species of landbirds are threatened endemics, *Elaenia ridleyana* Sharpe, 1888 (Noronha Elaenia) and *Vireo gracilirostris* Swainson, 1837 (Noronha Vireo), and four seabirds are nationally threatened, *P. lherminieri*, *Phaethon aethereus* Brandt, 1840 (Red-billed Tropicbird), *Phaethon lepturus* Daudin, 1802 (White-tailed Tropicbird) and *Sula sula* (Linnaeus, 1766) (Red-footed Booby) (Silva e Silva 2008; MMA 2022). Additionally, about 60 migrant and vagrant species have been recorded in this area (Silva e Silva 2008; Williams et al. 2017; Silva e Silva and Carlos 2019; Whittaker et al. 2019). The occurrence of these species and the importance of this archipelago for conservation have granted the islands the status of Important Bird Area (IBA – BR234; Devenish et al. 2009).

Despite a long history of research on the local avifauna (Silva e Silva 2008), there are few data about oceanic species using the waters off the archipelago. Previous works on Procellariiformes in the FNA have focused on a small breeding colony of *P. lherminieri* at the Morro da Viuvinha and the Morro de Leão islets (Mestre et al. 2009; Silva e Silva and Olmos 2010) or reported occasional records of several species (e.g. Soto and Silva 2001; Silva e Silva 2008). However, these records were made decades ago, including, for example, a poorly documented record of a *Fregetta tropica* (Gould, 1844) (Black-bellied Storm-Petrel) in the 19th century (Olmos 2000) and the most recent records of *P. lherminieri*, which date back to 2008.

In the current study, we present new records of procellariiform species and their history of occurrence in the FNA. Morphological and genetic tools were used to identify the specimens, supporting a richer contextualization about their occurrence patterns. We searched for previous records in the literature and in citizen-science platforms, to be able to better characterise the species occurrences in South Atlantic tropical waters. Finally, we discuss the influencing factors, focusing on the occurrence of pelagic birds in the FNA.

METHODS

We compiled records of Procellariiformes in the FNA from January 2018 to October 2023. These data were gathered through the local environment agency, Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), which carried out an authorized monitoring protocol (SISBIO no. 24381-23) to properly evaluate and collect data on stranded birds. All individuals were reported by the local community (e.g. residents, visitors, and environmental monitors) occasionally, which makes it impossible to estimate the frequency or density rate of strandings. Following Hurtado et al. (2020), clinical analyses were performed on each stranded individual to assess the health of the rescued birds. The analysis mainly looked for the presence of external and internal lesions, level of responsiveness, pectoral score, and presence of oiled, broken, or missing feathers. After the initial assessment, measurements were taken using precision metric callipers (always by LPSS), photographs were taken for identification, and, when adequate, birds were banded with standardized metal rings of the Centro Nacional de Pesquisa e Conservação de Aves Silvestres (CEMAVE; permit SNA no. 3258/14) following CEMAVE (2020) and Hurtado et al. (2020). Identifications were based firstly on external plumage and morphometry and considered the geographic distribution of species (e.g. Flood and Fisher 2013; Robertson et al. 2016; Flood et al. 2019; Howell and Zufelt 2019; Taylor et al. 2019). Individuals with severe lesions, in an unresponsive state (Hurtado et al. 2020), or with remitting cumulative stress were euthanized through anaesthetic chemical containment (under SISBIO no. 24381-23) and, along with those dead from natural causes, were frozen and sent to scientific collections to be prepared as specimens. Museum acronyms and abbreviations used for vouchered specimens: UFPE = Universidade Federal de Pernambuco, MZUSP = Museu de Zoologia da Universidade de São Paulo, T = tissue samples. Data on sex and breeding conditions were taken from these specimens.

Due to the close morphological similarities between *Fregetta tropica* and *Fregetta grallaria* (Vieillot, 1818) (White-bellied Storm-Petrel), we adopted a genetic approach to identify an individual of this species by comparing mitochondrial DNA (cytochrome b; Cytb) gene fragments to those available in GenBank. The genomic DNA from one *Fregetta* individual was extracted with the DNeasy Blood & Tissue kit (Qiagen) following the manufacturer's protocol. The DNA was visualized in 1% electrophoresis gel and stained with GelredTM to confirm the integrity of the extracted material, which was posteriorly quantified using a nano spectrophotometer Nanodrop 2000 (Thermo Scientific). The Cytb gene was amplified through PCR using

the L14764 (5' TGRACAAAAAATAGGMCCMGAAGG 3') and H6064 (5' CTCAGTTTTTGGTTTACAAGACC 3') primers (Sorenson et al. 1999). The PCR reaction was carried out with a 25 µL final volume containing: 12.5 µL of 2X Taq Pol Master Mix (Cellco), 1 µL of each primer (10 mM), 1 µL of magnesium chloride (50 mM), 4 µL of genomic DNA (40 ng/µL), and 6.5 µL of ultrapure water. The PCR cycle was modified from Robertson et al. (2007): an initial denaturation at 94 °C for 2 min, followed by 10 cycles at 94 °C for 15 s, 55 °C for 25 s and 72 °C for 2 min, then 20 cycles at 94 °C for 15 s, 50 °C for 25 s and 72 °C for 2 min. The fragments were visualized in 1.8% electrophoresis gel and stained with Gelred™ and purified using the NucleoSAP Kit (Cellco) following the recommended protocol provided by the manufacturer. The sequences were obtained using the ABI 3500 sequencer (Applied Biosystems) with the Bigdye Terminator v. 3.1 Kit (Applied Biosystems) following Robertson et al. (2007). These sequences were combined with those available in the GenBank of both *F. tropica* (accession no. KU558992 to KU558996, AF076053) and *F. grallaria* (accession no. KU559001, KU559000, AF076054, KU558997 to KU558999). The sequences were edited and aligned using the ClustalW algorithm (Thompson et al. 1994) implemented in BioEdit v. 7.0 (Hall et al. 1999), and the phylogenetic relationships were investigated through a Bayesian approach in the Beast v. 2.4.7 package (Bouckaert et al. 2014) using *Aptenodytes patagonicus* Miller, 1778 (King Penguin) (GenBank accession no. AF076044) as the outgroup. Three independent runs with 5 million MCMC were combined using the LogCombiner in Beast with a 25% burn-in. The best evolutionary model was determinate in jModelTest v. 2.1.7 (Darriba et al. 2012) under the Akaike Information Criterion (HKY + I). The genealogical relationships between the haplotypes were investigated through a haplotype network using the TCS method in PopART (Clement et al. 2002; Leigh and Bryant 2015).

Additionally, we also performed genetic analyses for a dark-boddied *Ardenna* sp. (grey Shearwater) individual, aiming to complement our morphological species identification and rule out the possibility of confusion between species by using the cytochrome c oxidase subunit I (COI) gene. The AWCF1 (5' CGCY TWAACAYTCYGCCATCTTACC 3') and AWCR6 (5' ATTCCTATGTAGCCGAATGGTTCTTT 3') primers were amplified (Patel et al. 2010). The PCR reactions were the same as used for Cytb amplification (described above), and the PCR cycle followed Patel et al. (2010). The fragments were visualized in 1.8% electrophoresis gel and stained with Gelred™ and purified using the NucleoSAP Kit (Cellco), following the recommended protocol provided by the manufacturer. The purified amplicons were diluted to a final concentration of 20 ng/µL and Sanger sequenced with Bigdye Terminator v. 3.1 Cycle Sequencing Kit (Applied Biosystems) using an ABI 3500 sequencer (Applied Biosystems). The consensus sequence was obtained as described above for *Fregetta*, and this sequence was compared to available sequences in the GenBank database (accession no. MK262685, MK262619, MK262580, MK262556, MK262520, MK262405, MK262344, MK262328, MK262239, MK262163, MK262118, MK262112, MK262079, MK262039, MK261983, MK261958, MK261911, MK261900, MK261886, MK261813, JK176048, JN801371, and JN801370). To investigate genealogical relationships, haplotype networks were obtained using the TCS method in PopART (Clement et al. 2002; Leigh and Bryant 2015). Despite these efforts, we were unable to apply genetics to other recorded specimens, and in these cases, identification was based on morphological characters.

After identifying the new records, we reviewed the procellariiform distribution and occurrence history for the species described in this work, including citizen-science platform databases (eBird 2023; iNaturalist 2023; WikiAves 2023). For this step, we used a radius of 290 km from the archipelago (Olmos 2000) and all the records found over time within these platforms. We considered only observations documented by photographs or audio recordings to confirm a bird observation, and we did not include observer's checklists without media as valid records. Geographical range mapping was based on BirdLife International (<https://www.iucnredlist.org/>) and GBIF (<https://www.gbif.org/>) data.

RESULTS

We recorded five stranded individuals of four species of Procellariiformes in several localities of the FNA (Figure 1; Table 1): single *Fregetta tropica melanoleuca* Salvadori, 1908 (Gough Storm-Petrel; $n = 1$: shallow waters); *Ardenna grisea* (Sooty Shearwater; $n = 1$: on land) and *Hydrobates leucorhous* (Vieillot, 1818) (Leach's Storm-Petrel; $n = 1$: at-sea shipboard); and two *Puffinus lherminieri* (Audubon's Shearwaters; $n = 1$: on land; $n = 1$: on the beach). The general health assessments found no oiled birds, broken feathers, dermatitis and vesicles, or cardiorespiratory irregularities, but did find all individuals to be unresponsive. We found only one documented observation of *F. tropica* in iNaturalist (2023). Since the last studies for *P. lherminieri* were carried out 15 years ago (Silva e Silva and Olmos 2010), we have verified six documented records for these procellariiform species in the FNA. We then provide details for the accounts of each species, remarks, identification, figures, and context of the records.

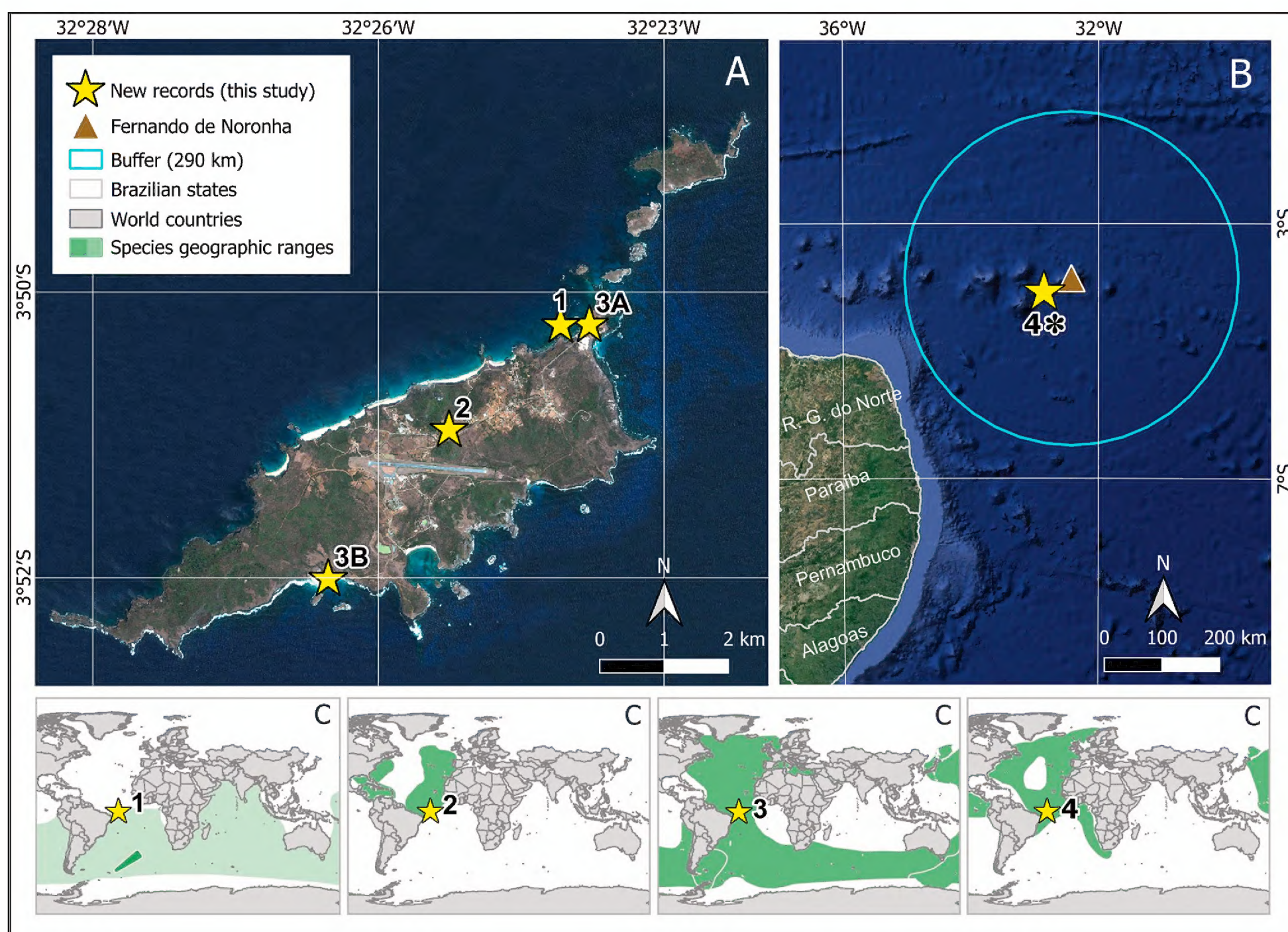


Figure 1. Map showing the new records of each bird species of Procellariiformes. **A.** Fernando de Noronha archipelago (FNA), Brazil. **B.** 290 km buffer area off the FNA. **C.** World distribution overview. 1 = *Fregetta tropica melanoleuca* (overlaid with *F. tropica* in light green); 2 = *Ardena grisea*; 3 = *Puffinus lherminieri* (3A = first and 3B = second individual recorded); 4 = *Hydrobates leucorhous*. * = indicates geographic position not precise.

Order Procellariiformes
Family Oceanitidae

***Fregetta tropica melanoleuca* Salvadori, 1908**

Gough Storm-Petrel
Figures 2, 3

New record. BRAZIL – Pernambuco • Fernando de Noronha (Environment Protected Area), Santo Antônio Port; 03°50'4"S, 32°24'16"W; 0 m alt.; 01.VII.2021; L.P.S.Santos & T.A.Rocha leg.; shallow waters of port area, 250 m off coast; hand caught; GenBank accession no. OR343918; 1 young adult ♀ (ovary 5 × 2 mm, straight oviduct 0.5 mm and tiny ova <0.5 mm, without bursa of Fabricius), UFPE-6454/T-2429.

Remarks. One individual was found alive by a resident while canoeing at 07:00 (local time) and taken to ICMBio. Upon examination, the bird had new feathers growing (emerging calamus) on the upperwing coverts and, despite presenting a good body condition (judged by pectoral muscle inspection), it was unresponsive with an open, oblique fracture on the left tarsometatarsus (Figure 2). The bird was euthanized, frozen, and sent to the UFPE ornithological collection.

Identification. Identifying *Fregetta* taxa is complex (Murphy and Snyder 1952; Cibois et al. 2015; Robertson et al. 2016). The white-bellied individuals of *Fregetta* sp. in the Atlantic Ocean are either *F. t. melanoleuca* or the similar *Fregetta grallaria leucogaster* (Gould, 1844) (Inaccessible Storm-Petrel) (Robertson et al. 2016; Howell and Zufelt 2019; Harrison et al. 2021). Measurements and subtle details in plumage distinguish these taxa, and *F. t. melanoleuca* is slightly smaller than *F. g. leucogaster* (Flood and Thomas 2007; Howell and Zufelt 2019).

The studied specimen presented generally smaller measurements when compared with other *F. tropica* individuals, especially of the wing (e.g. Beck and Brown 1971; Jouventin et al. 1985; Hahn 1998; Flood and Thomas 2007; Sausner 2015; Bretagnolle et al. 2022). The toes protrude beyond the tail tip when projected backwards, and the black vent and narrow white fringes to the scapulars to mantle fit well with

Table 1. Morphometric data of the recorded species of Procellariiformes in the Fernando de Noronha archipelago. Linear measurements are in mm. Museum collections: UFPE = Universidade Federal de Pernambuco; MZUSP = Museu de Zoologia da Universidade de São Paulo.

Species	<i>Fregetta tropica melanoleuca</i>	<i>Ardenna grisea</i>	<i>Puffinus lherminieri</i>	<i>Puffinus lherminieri</i>	<i>Hydrobates leucorhous</i>
Museum collection or band code	♀ UFPE-6454	♀ UFPE-6473	Band M35767	Band M35766	♂ MZUSP-135.555
Date of record	2021-07-01	2021-05-17	2019-11-23	2021-12-19	2021-12-26
Mass (g)	35.0	628.0	205.0	151.0	30.0
Total length	224.0	482.0	310.0	309.0	197.0
Head length	40.9	103.0	—	68.6	41.5
Bill length (culmen)	13.1	44.0	29.9	28.1	16.0
Bill height	6.1	15.0	—	9.4	7.4
Bill width	8.1	14.0	10.4	9.8	5.3
Nare-tip	6.7	33.0	23.4	20.2	8.7
Nose tube height	—	—	—	—	6.7
Wing chord	139.0	312.0	—	178.9	160.0
Wingspan	393.0	1041.0	—	633.0	472.0
External tail	—	—	—	—	74.0
Middle tail	83.0	81.0	97.2	78.6	59.9
Tarsus length	42.6	64.0	39.9	38.5	24.8
Middle toe right	—	—	—	46.1	26.5
Middle toe left	—	—	—	—	26.8

Figure 2. *Fregetta tropica melanoleuca* collected in Fernando de Noronha (1 July 2021; UFPE-6454), Brazil. **A.** Lateral view, showing poorly developed white chin. **B.** Ventral view, showing toes extending past tail tip when projected backwards and undertail coverts with black vent. **C.** Right dark foot in dorsal view. **D.** New feathers growing (emerging calamus) on upperwing coverts. **E.** Ventral overview. **F.** Oblique fracture on left tarsometatarsus. **G.** Right dark foot in palmar view. **H.** Oral cavity. **I.** Dorsal overview, highlighting narrow white fringe pattern from scapulars to mantle.



Howel and Zufelt's (2019) description of *F. t. melanoleuca*. Despite this, morphometrics alone was not able to distinguish between *Fregetta* spp. Genetic data of 961 bp obtained from the Cytb gene confirmed the identity of this specimen as *F. tropica* (99% of similarity through the BLASTn tool in GenBank; Figure 3A). The haplotype network demonstrated that the FNA individual has a unique haplotype, separated by seven mutational steps from *F. tropica tropica* (Gould, 1844) and by three mutational steps from the other Gough Island specimens (Figure 3B). Thus, our data confirm the subspecies to be *F. t. melanoleuca*.

Distribution. The breeding area and the at-sea distribution of the *F. t. melanoleuca* is restricted to the Tristan da Cunha region (Beck and Brown 1971; Flood and Fisher 2013; Flood and Thomas 2007; Howell and Zufelt 2019). Wide dispersion is expected, despite offshore distribution and seasonal movements of

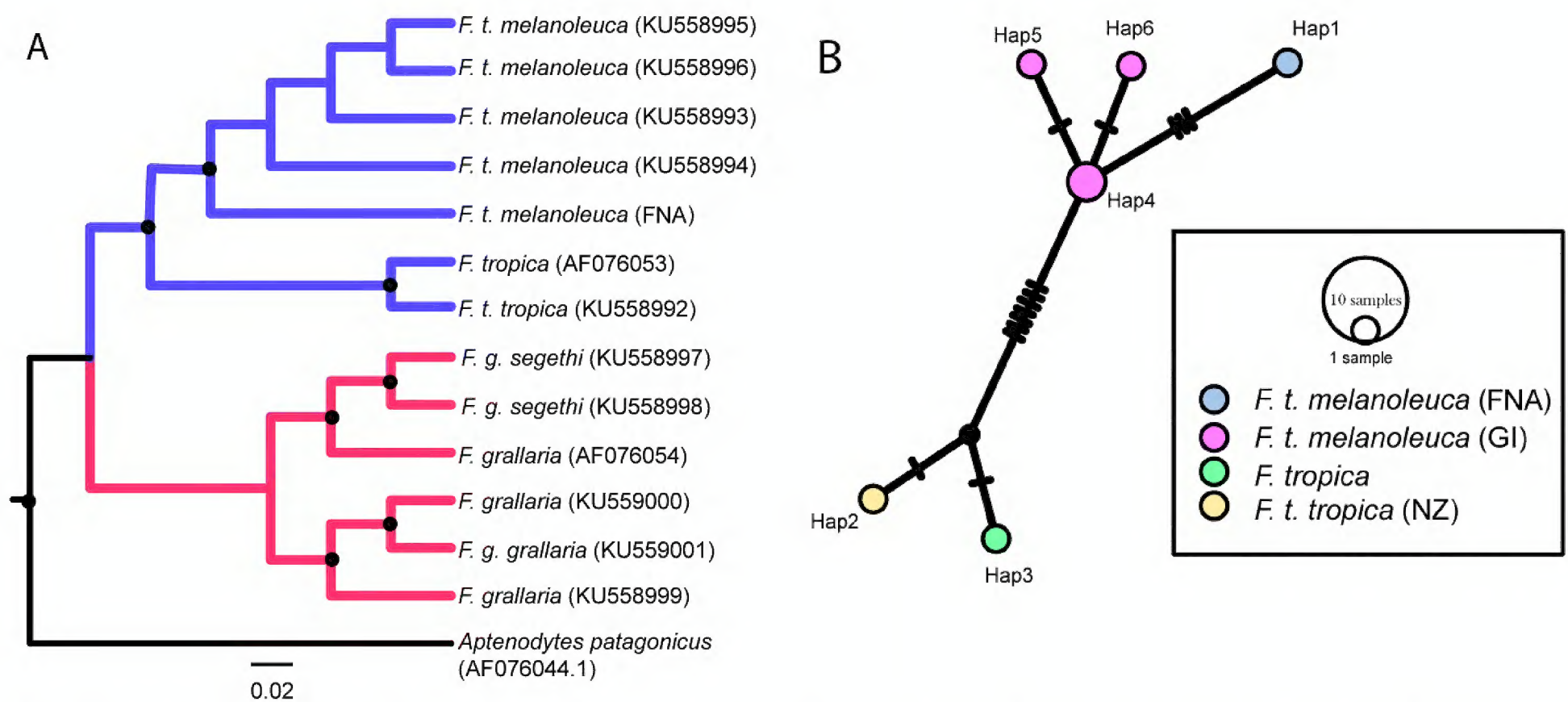


Figure 3. Genetic data of cythochrome b (Cytb) from *Fregetta tropica melanoleuca*. **A.** Bayesian topology of *Fregetta* spp. The black circles represent posterior probabilities equal to or higher than 0.9. **B.** Haplotype network of *F. tropica* subspecies. The different colours represent the sample sites, the black bars represent the mutations, and the black circle represents lost or non-sampled haplotypes. (FNA: Fernando de Noronha archipelago, GI: Gough Island, NZ: New Zealand).

this subspecies in the Atlantic remain mostly unknown, a problem compounded by difficulties in at-sea identification of *F. t. melanoleuca* and *F. g. leucogaster* (Shirihai 2008; Spear and Ainley 2007; Flood and Fisher 2013; Howell and Zufelt 2019). While subspecies have not been fully recognized, the records of *F. tropica* include regions in middle and North Atlantic (Guris et al. 2004; Banks et al. 2006; Flood and Thomas 2007; eBird 2023; iNaturalist 2023). In Brazil, there are offshore records for the *F. tropica* near Saint Peter and Saint Paul Rocks and the Brazilian states of Rio Grande do Sul, Rio de Janeiro, Espírito Santo, Bahia, and Piauí (Sick 1997; Vooren and Brusque 1999; Olmos 2000; Barbosa Filho and Vooren 2007; Petry et al. 2016; Alvarenga 2018; Franz et al. 2018; Daudt 2019; eBird 2023; WikiAves 2023; Valls et al. 2023), although these records may encompass both subspecies. Previous records of *F. tropica* in the vicinity of the FNA include one reported by Olmos (2000) and another in October 2022, approximately 220 km southeast of the archipelago (<https://www.inaturalist.org/observations/140284651>). Thus, this individual constitutes the second record for *F. tropica* in the FNA and the first identification of a *F. t. melanoleuca* in Brazil (Pacheco et al. 2021), stating the northernmost record ca. 4,200 km from the Tristan da Cunha region. The FNA specimen lacked the bursa of Fabricius and presented small ova and fresh plumage, which suggests that it was a dispersing immature individual.

Family Procellariidae

***Ardenna grisea* (Gmelin, 1789)**

Sooty Shearwater

Figures 4, 5

New record. BRAZIL – Pernambuco • Fernando de Noronha (Environment Protected Area), Vacaria Village; 03°50'57"S, 32°25'12"W; 65 m alt.; 17.V.2021; L.P.S.Santos & T.A.Rocha leg.; found inland, ca. 770 m from coast; hand caught; GenBank accession no. OR337935; 1 young adult ♀ (ovary 7 × 3 mm, straight oviduct 0.5 mm and indistinguishable ova <0.5 mm, without bursa of Fabricius), UFPE-6473/T-2448.

Remarks. The bird was found at night by a local resident in an open, semirural area on the main island. It had been cornered by two domestic dogs and was taken to ICMBio the following morning. It was an exhausted and dehydrated young adult with dirty plumage and injuries, including a lesion in the left eye and on both legs, with torn webs and no nails, probably resulting from a stunned landing and the dog attack (Figure 4). Initial handling was followed by the treatment of lesions, oral rehydration, and data collection. After about 1 h, the bird died and was sent to the UFPE ornithological collection.

Identification. Measurements of bill, wingspan, and total length were found to be larger than *Ardenna tenuirostris* (Temminck, 1836) (Short-tailed Shearwater) (Souto et al. 2008; Howell and Zufelt 2019), which supports the identification as *A. grisea*. With respect to its external morphology, this bird had a more squared than rounded cranium, dark-grey bill, and a slightly lighter throat region. The entire ventrum was light grey,

Figure 4. *Ardenna grisea* collected in Fernando de Noronha (17 May 2021; UFPE-6473), Brazil. **A.** Ventral view, showing dirty plumage. **B.** Throat and chest in light-grey plumage. **C.** Right dark-grey upperwing coverts. **D.** Right underwing with white extension and darker axillary. **E.** Lateral view, showing dark-grey bill and slightly lighter throat. **F.** Lesions found on foot and digits. **G.** Dorsal view, showing mantle, rump, wedged-shaped tail, and uppertail coverts. **H.** Oral cavity. **I.** Right foot in dorsal view. **J.** Right foot in palmar view, showing central digit lesions.



the underwings had a large white extension, but dark at the base of the wing, and upperwing coverts were dark grey. The tail was wedged-shaped, and the foot had a dark-grey palmar region and light-pink dorsal region. The barcode region of 645 bp confirmed the identification of this specimen as *A. grisea*, and no indication of genetic structure was found between New Zealand, Australia, and the FNA samples (Figure 5).

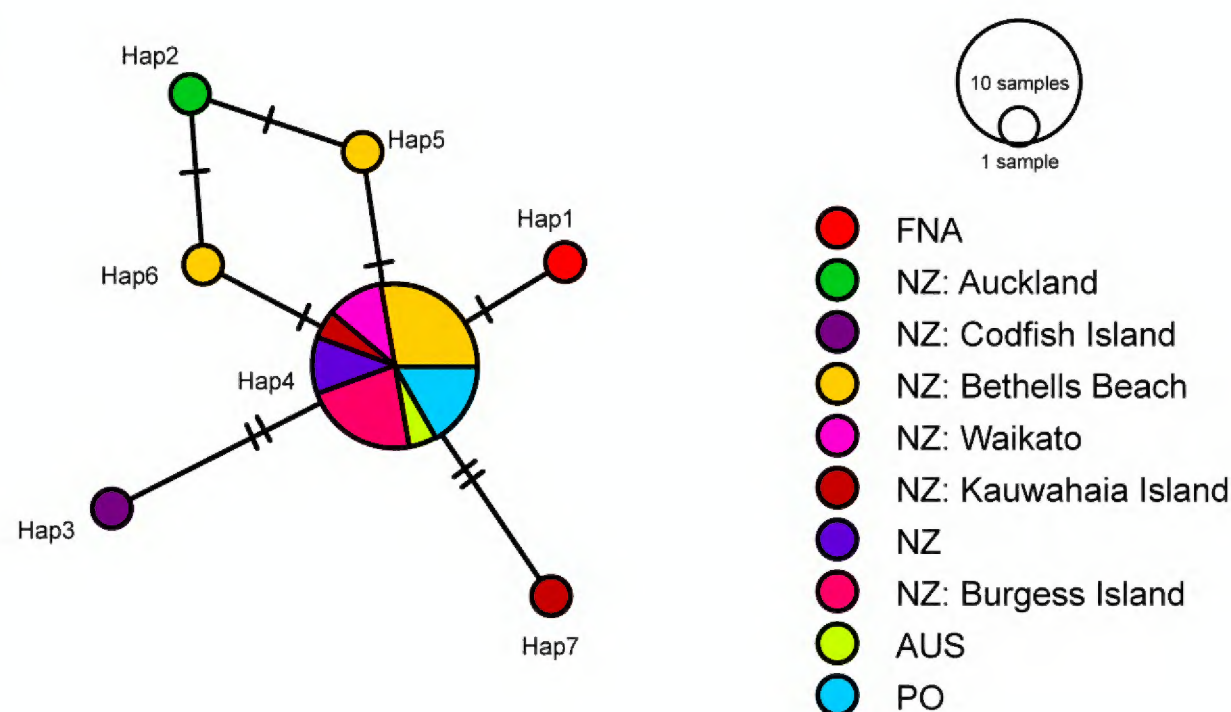
Distribution. Breeding habitats of the *A. grisea* are well known in the Indo-Pacific region and the islands of southern South America, but more information is needed on dispersal and non-breeding movements (Hamilton et al. 1997; Jones 2000; Richdale 2009; Shaffer et al. 2009). The occurrence of *A. grisea* in Brazilian waters is expected, as this species undertakes a 30,000 km trans-equatorial migration between southern South America and the North Atlantic (Cooper et al. 1991; Hedd et al. 2012). As reported previously, this species passes along the south, southeast (Belton 2000; Neves et al. 2006; Barbieri 2009; Melo et al. 2012; Daudt et al. 2017; Daudt 2019; eBird 2023; iNaturalist 2023; WikiAves 2023; Valls et al. 2023), and northeast Brazil's coast (Lima et al. 2004; Sousa et al. 2005; Mariani et al. 2019; Petersen 2021; eBird 2023; WikiAves 2023). Since a dead bird was found in FNA in 1995 (Schulz-Neto 1998; MZUSP 75463), this is the second documented occurrence of *A. grisea*, suggesting the migration of an immature individual through the region.

Puffinus lherminieri Lesson, 1839

Audubon's Shearwater
Figures 6, 7

New records. BRAZIL – Pernambuco • Fernando de Noronha (Environment Protected Area), Santo Antônio's Port; 03°50'04"S, 32°24'01"W; 20 m alt.; 23.XI.2019; L.P.S.Santos & C.L.B.Luna obs.; inland, ca. 100 m from coast; hand caught; 1 adult; unknown sex; CEMAVE M35767 band • Fernando de Noronha (National

Figure 5. Haplotype network of cytochrome c oxidase subunit I (COI) dataset of *Ardenna grisea*. The different colors represent the sample sites, and the black bars represent the step mutations. (FNA: Fernando de Noronha archipelago, Brazil; NZ: New Zealand; AUS: Australia; PO: Pacific Ocean).



Marine Park), Leão Beach; ca. 03°52'12"S, 32°26'13"W; 1 m alt.; 19.XI.2021; L.P.S. Santos obs.; infralittoral sandy region; hand capture; 1 adult; unknown sex; CEMAVE M35766 band.

Remarks. The first individual was brought to ICMBio by a local resident who found it on land, in a restaurant in the Santo Antônio's port region. The individual was unresponsive, but without injuries and with a good pectoral score (Figure 6). After initial assessment, the bird became responsive and was sent for release at 16:40 (local time) at Praia do Leão (ca. 03°52'S, 32°25'W). We considered this site suitable for release as it presents less disturbance by humans and is close to the islands of Morro do Leão and Morro da Viuvinha, which are the known breeding areas. The finding of this individual was somewhat unexpected, as the bird was away from known nesting areas and in an area with many artificial lights, vessels, and human activity. There had been strong trade winds and northward-moving swells on the ocean on this day (SurfGuru 2022), and we suppose that these conditions may have disoriented this bird orientation and led to its stranding. The second bird was reported at 7:11 (local time) by the Fundação Pró-TAMAR team while monitoring sea turtle nests at Praia do Leão (Figure 7). The bird was found in a tired state but with a good body score. Following our protocol, we successfully released the bird at 16:32 (local time) at the same location mentioned above.

Identification. Morphological characters overlap in the *Puffinus assimilis-lherminieri* complex (Little Audubon's Shearwaters) (Austin et al. 2004). Plumage and measurements of our specimens were similar to previous reports from the FNA (Soto and Filippini 2003; Mestre et al. 2009; Silva e Silva and Olmos 2010), as well as general measurements of *P. lherminieri* from elsewhere (Howell and Zufelt 2019; Ramos et al. 2021). The birds showed a well-defined hood and initial whitish area on the face (worn plumage) in front of the eye, which is characteristic of *P. lherminieri*. Broad, dark underwings margins were evident, and the primaries were unremarkably light. Longer tail with dark undertail coverts were also perceptible. The foot

Figure 6. First rescued specimen of *Puffinus lherminieri* in Fernando de Noronha (23 November 2019; M35767 band code), Brazil. **A.** Ventral overview, showing well-defined hood, initial whitish area on face in front of eye, and dark undertail coverts. **B.** Left wing in ventral view, showing broader dark underwing margins. **C.** Dorsal view of tarsometatarsus and webbed foot, light pinkish with black spots.



Figure 7. Second rescued specimen of *Puffinus lherminieri* in Fernando de Noronha (19 November 2021; M35766 band code), Brazil. **A.** Stranded bird found on beach. **B.** Right wing. **C.** Left wing, showing broader and darker underwing margins and unremarkably light primaries. **D.** Left wing in dorsal view. **E.** Lateral view, showing well-defined hood with initial whitish area on face (worn plumage) in front of the eye. **F.** Lateral view, showing side and flank. **G.** Ventral view, noting chest, belly, and uppertail coverts. **H.** Undertail coverts and longer dark tail. **I.** Dorsal view, showing tail. **J.** Tarsometatarsus and toes with black central lines, but note the pinkish web. **K.** Lateral overview, highlighting overall light pinkish webbed foot. **L.** Lateral cranial view, showing well-defined hood. **M.** Oral cavity.



showed a colour pattern resembling that described by Silva e Silva and Olmos (2010) for this specie: light pinkish overall with black spots.

Distribution. *Puffinus lherminieri* occurs in the tropical and subtropical western Atlantic Ocean, breeding in the Bahamas, the West Indies, islets east of Nicaragua (Providencia Island), and islands off northwest Panama (Kirwan et al. 2020). Small populations are also known in Fernando de Noronha and, formerly (no recent records) on the Itatiaia Islands off eastern Brazil (Efe and Musso 2001; Efe 2004). Lopes et al. (2014) pointed out several potential sites for this species along the Brazilian coast, especially in the states of Rio de Janeiro, Espírito Santo, Bahia, and Pernambuco. Notably, the individuals presented here are the only documented records of *P. lherminieri* in the FNA since 2008. Young and adult individuals have been reported locally in the archipelago on sandy beaches, including Boldró, Sueste, and Leão (Soto and Filippini 2003; Antas et al. 1990; Silva e Silva and Olmos 2010).

Family Hydrobatidae

***Hydrobates leucorhous* (Vieillot, 1818)**

Leach's Storm-Petrel

Figure 8

New record. BRAZIL – **Pernambuco** · offshore; geographic coordinates unknown; 26.XII.2021; L.P.S. Santos & T.A. Rocha leg.; shipboard observation; hand caught; 1 adult ♂ (testicles 2 × 2 mm, without bursa of Fabricius), MZUSP 115.315.

Remarks. A storm-petrel was handed to ICMBio at 15:00 (local time) on 26 December 2021 by the skipper of one of the cargo vessels on the route between Recife and the FNA. The bird was found in the morning by the crew on the deck of a large vessel (c.160 m² in area) during the crossing (ca. 540 km; duration ca. 40 h). The geographic coordinates of the stranding are unknown but by the time of detection, we can judge that the bird arrived on the ship while the ship was within 290 km of the archipelago. The bird was unresponsive and without external injuries. The left webbed foot had an external anomaly between the central and inner toes (Figure 8), which has been reported with some frequency in the species (Post 1998). When the bird's health condition improved, measurements and photos were taken. The bird died after 2 h while being stabilized. The specimen to send for the scientific collection of the Museu de Zoologia da Universidade de São Paulo.

Identification. The bird was identified as *H. leucorhous* due to its short legs not protruding beyond the tail, black-webbed feet, and forked tail. Other characters included accentuated angles on the wing silhouette, semicircular wing bars almost completely covering the remiges, white rump with a poorly developed pelvic-caudal white bar (2–3 score), a dusky median line, and no white on the primary coverts (Flood et al. 2017, 2019; Wallace et al. 2017; Howell and Zufelt 2019).

Distribution. This species breeds broadly in the northern hemisphere and crosses the equator during its non-breeding period (Ainley 1980; Howell and Zuffet 2019; Pollet et al. 2021). These birds also are considered to have a wide geographic occurrence, but a lack of knowledge on their distribution pattern persists (Huntington et al. 1996; Flood and Fisher 2013; Howell and Zufelt 2019; Underhill et al. 2022;). In Brazil, *Hydrobates leucorhous* has been reported (Lima et al. 2004; Albano and Girão 2011; Lees et al. 2015; Alvarenga 2018; Daudt 2019; eBird 2023; iNaturalist 2023; Santos et al. 2023; WikiAves 2023), and then mostly overwintering off northeast region (Pollet et al. 2014, 2019). Murphy (1915) reported *H. leucorhous* around Atol das Rocas in 1913 (ca. 200 km from the FNA), and Soto and Silva (2001) found beached individuals in the port of the FNA in 1999. Our observation reported here is the third record of this species in the FNA. Considering the low body mass, small reproductive organ, and lack of the bursa of Fabricius, we suggest that our specimen is a non-breeding adult.

DISCUSSION

Considering the question “who is looking out for them?” we instigated the detection of pelagic and visitant bird species over time in the FNA. Will there be few additional records in the coming years because the species are not very frequent or because monitoring work focused on pelagic birds is scarce? In fact, the occurrence of many species of Procellariiformes is expected in the tropical Atlantic, but these birds have been rarely reported. Thus, we are able to provide new records in the FNA of *Fregetta tropica* after a century, *Ardenna grisea* after 26 years, *Puffinus lherminieri* after 11 years, and *Hydrobates leucorhous* after 22 years. This is likely possible on account of a lack of continuous surveys with few birders and ornithologists covering large regions of the ocean (e.g. Daudt 2019; Barbosa Filho and Vooren 2007). Without effective surveys, we cannot understand further patterns or confirm how often these species occur off the mainland; if they are abundant, seasonal, or only occasional visitors to the FNA. Tracking work has verified the species movement through the archipelago and citizen-science platforms present several observer's checklists, which also include other procellariiform species. This supports the hypothesis that oceanic species can be

Figure 8. *Hydrobates leucorhous* collected in Fernando de Noronha (26 December 2021; MZUSP 115.315), Brazil. **A.** Lateral view, showing dark tubenoses and bill, with a darker cranial and neck region. **B.** Dorsal overview, highlighting semicircular wing bars almost completely covering remiges. **C.** Ventral overview, showing forked tail and no white on primary coverts. **D.** Tail and undertail coverts with lighter plumage. **E.** Dorsal view, showing mantle, white rump with pelvic-caudal white bar poorly developed, and forked tail while open. **F.** Closed feathers in dorsal view, showing external aspect with forked tail and accentuated angles on wing silhouette, as a dusky median line on white rump. **G.** Oral cavity. **H.** Left black-webbed foot in dorsal view, showing external anomaly between central and inner toes. **I.** Right black-webbed foot in dorsal view. **J.** Dorsal overview. **K.** Ventral view, showing chest, belly, tail, and light feathers in uppertail coverts.



better detected. The FNA includes the largest and most inhabited of the four Brazilian oceanic islands and is a potential site to apply at-sea bird surveys. The archipelago is recognized as area that several migratory species use as a stopover in the South Atlantic Ocean (Silva e Silva 2008; Silva e Silva and Carlos 2009; Williams et al. 2017; Whittaker et al. 2019). Additionally, more in-depth assessments of the health conditions of these species could provide valuable information, as presented here.

Seamounts and offshore oceanic archipelagos create dynamic and ephemeral oceanographic conditions that attract seabirds (Longhurst and Pauly 1987; Feitosa and Bastos 2007; de Souza et al. 2013; Santana 2015). Few systematic investigations relating occurrence patterns of Procellariiformes to environmental characteristics have been carried out in Brazil (e.g. Barbieri et al. 2019; Daudt 2019). The seamounts along the Fernando de Noronha chain are a great area to focus such investigations. Several studies in the northeast of Brazil have reported many widespread species (Veit 1995; Azevedo Junior et al. 2001; Carlos et al. 2005; Carlos 2009; Pereira et al. 2008; Albano and Girão 2011; Lees et al. 2015; Mariani et al. 2019; Petersen 2021), such as the *Calonectris borealis* (Cory, 1881) (Cory's Shearwater) and *Puffinus puffinus* (Brünnich, 1764) (Manx Shearwater), which have been rarely reported in the FNA (Nacinovic and Teixeira 1989; Oren 1982; Barbosa Filho and Vooren 2007; González-Solís et al. 2007; Silva e Silva 2008; Guilford et al. 2009; eBird 2023; iNaturalist 2023). For instance, Barbosa Filho and Vooren (2007) recorded *Oceanites oceanicus* (Kuhl, 1820) (Wilson's Storm-Petrel) as the second most abundant species during at-sea surveys, crossing the FNA to the Saint Peter and Saint Paul Archipelago (00°55'N, 29°20'W). Therefore, continuous monitoring focusing on at-sea surveys has the potential to increase our knowledge of seabirds, and we strongly suggest improved survey methods.

The factors influencing the presence of pelagic birds around oceanic islands off Brazil should be further investigated. The occurrence of Procellariiformes in temperate–polar latitudes is related to the highly productive waters (Chown et al. 1998; Davies et al. 2010). In tropical regions, seasonal changes in wind intensity and direction increases nutrients and ephemeral habitats for seabirds (Longhurst and Pauly 1987; Campos et al. 1996; Chown et al. 1998; Carlos 2006, 2009; Davies et al. 2010). Although the small sample size recorded here, we wonder if the bird strandings are related to seasonal dynamics or their breeding cycles. Some pelagic species explore larger areas, especially during post fledging dispersal (Schreiber and Burger 2001), as known for *A. grisea* (Hedd et al. 2012; Shaffer et al. 2006) and *H. leucorhous* (Pollet et al. 2014, 2019), which overlap the Brazilian oceanic islands in non-breeding seasons.

Each of our specimens exhibited a unique haplotype, presenting a star shape (one central haplotype with a higher frequency surrounded by unique haplotypes), typical of a population that passed through a recent expansion event (Avice 2000). The COI data from the *A. grisea* specimen suggest a connection with the South Atlantic colonies and is divergent from Pacific Ocean populations. The FNA specimen found in May corroborates Hedd et al. (2012), who point out that *A. grisea* migrates north from the Falkland Islands between March and April. *Ardenna grisea* is the most common procellariiform in southeastern South America, with large populations and a regular intercontinental migratory pattern (Reyes-Arriagada et al. 2007; Hedd et al. 2012, 2014). Thus, more records for this specie should be expected in tropical waters.

As expected, our specimen of *F. tropica* was more closely related with Gough Island populations than with the New Zealand, although it presented more mutation bars compared to other Gough Island samples. From these results we speculate that there is a possible connection with the closer region, the Tristan da Cunha, or Inaccessible islands, where *F. tropica melanoleuca* is also present. We also reflect that our specimen was a late-dispersal individual (December), as northward movements normally occur in May to October, despite this is still unclear (Flood and Thomas 2007; Robertson et al. 2016; Howell and Zufelt 2019). The FNA individual has a more differentiated lineage that diverged during the cladogenetic event that separated *F. t. melanoleuca* and *F. t. tropica*, and this difference highlights the shallow genetic differentiation between them (Robertson et al. 2016). Herein, our data confirm a latitudinal expansion of 34° to the north and the first record of the *F. t. melanoleuca* from Brazil (Pacheco et al. 2021). No observations of *F. t. melanoleuca* were present in citizen-science platforms that we searched, and we reinforce the need for careful identification. With further research, it may be possible to better follow species movements in tropical waters and confirm a hitherto unknown connection between the Equatorial Atlantic and higher latitude areas. Genetic tools can be used to identify species and uncover cryptic species and subspecies (e.g. Pereira et al. 2016; Taylor et al. 2019).

Both individuals of *P. lherminieri* in our study were found in November and may have been from a resident population, as the breeding season of this species extends from August to December in the FNA and on the Brazilian mainland (Efe and Musso 2001; Silva e Silva and Olmos 2010). However, we do not reject the hypothesis that they were nonbreeding adults from other areas, as January to July breeding seasons are known in larger colonies in the Caribbean (Mackin 2016; Howell and Zufelt 2019; Ramos et al. 2021). There are interannual variations in the numbers of active nests and adults present in colonies (Soto and Filippini 2003; Mestre et al. 2009; Silva e Silva and Olmos 2010), as Silva e Silva and Olmos (2010) found only two non-breeding adults in November 2004 and 25 adults with 10 active nests in October 2005 in the FNA. Nonetheless, we presume that the local population has been in decline because expeditions carried out semi-annually by ICMBio/CEMAVE found no active nests in local colonies and other regions in 2018–2021. However, more recently an active nest was seen in August 2022 and October 2023 (LPSS and PPS pers. obs.), and calling adults were recorded by acoustic monitoring (LPSS and CLBL pers. obs.), which indicates that *P. lherminieri* is still breeding in the FNA, at least in small numbers.

Non-breeding individuals of *H. leucorhous* occur mainly in September to April in the tropical Atlantic (Huntington et al. 1996; Howell and Zufelt 2019). Our specimen was found in December, as are most records on citizen-science platforms close to this period in this region. Pollet et al. (2014) noted that fisheries discharge can attract *H. leucorhous*. We corroborate that studies performed alongside fishing can add seabird records, besides measure the influence of these activities on pelagic species. Encouraging the recording of seabirds during tourism and birdwatching can add distribution data in the FNA. Citizen-science has become an important resource of bird records (Trumbull et al. 2000; Earp and Liconti 2020). We were able to find seven remarkable records without media in citizen-science platforms, including *F. tropica* in 2017 ($n = 1$: at-sea observation), *P. lherminieri* in 2018 ($n = 2$: on land), and, particularly, *H. leucorhous* in 2007, 2017, 2019, and 2020 ($n = 4$: offshore) (eBird 2023). More records were found throughout the archipelago in GBIF (2023), which suggests that these and other procellariiform species are more frequent in the FNA than reported in the literature.

There is still much information on pelagic birds in the FNA to be discovered. Further surveys and research are needed to better understand species' distribution, in support of conservation efforts. This archipelago has an extensive area of national marine park near human occupation zones. Anthropization intensely increased from 2020 to 2023, and one of the most negative changes, besides the loss of vegetation, is the increase in light pollution. This problem is a critical cause of collision mortality and disturbs the circadian cycle of birds; it is recognized as a threat to seabirds worldwide (Reed et al. 1985; Troy et al. 2013; Cabrera-Cruz et al. 2018; Wilhelm et al. 2021). Furthermore, light pollution may be an overlooked cause of population declines in *P. lherminieri*, which is nocturnal, and is in addition to the well-known threat of predation by introduced populations of rats, cats, and tegu lizards (Gaiotto et al. 2020). The role of environmental agencies, such as ICMBio, in monitoring fauna health is crucial. Surveys focused on stranding birds are also in accordance with the National Action Program based on the Agreement on the Albatrosses and Petrels Conservation (ACAP 2022; ICMBio 2022) and the National Action Program for Seabird Conservation (PAN Aves Marinhas; ICMBio 2022), which consider the FNA as an important bird area. Population declines in procellariiform species are notorious for being global in scale, pointing them as one of the most threatened groups among birds (Croxall et al. 2012; Rodríguez et al. 2019). Our study reports *A. grisea* (Near Threatened) and *H. leucorhous* (Vulnerable) (IUCN 2023), and the nationally threatened *P. lherminieri* (Critically Endangered) (MMA 2022).

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ADDITIONAL INFORMATION

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

This work was developed according to SISBIO no. 24381-23 authorization and SNA no. 3258/14 banding procedures.

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Data availability

All data that support the findings of this study are available in the main text.

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